

## Thermal Conductivity and Electrical Resistivity of Copper-Beryllium Alloys

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Cryogenic deuterium-tritium (DT) fuel layers will be required in the target capsules in order to achieve ignition on NIF. To fabricate the complete ignition target, one must devise a way to produce a uniform spherical cryogenic DT layer inside the capsule. The beta-layering process can produce the required layer automatically. However, a perfectly symmetric, spherical beta-layer results only if the thermal conductivity  $\kappa_T$  of the capsule wall material is high enough to ensure a spherical isothermal boundary at the outside surface of the DT layer. Unfortunately, in indirect drive, the cryogenic cooling must be outside the hohlraum and the thermal boundary of a cylindrical hohlraum could imprint onto the cryogenic layer, making it unacceptably thicker at the equator where the DT is physically closer to the hohlraum wall. In this case, the hohlraum itself must be 'thermally shimmed' to make it appear spherical to the DT layer. In practice, this is not easily accomplished and is a compelling reason for using a spherical (aka 'tetrahedral') hohlraum. In addition, gravitationally induced thermal convection currents in the hohlraum gas tend to cause asymmetric cooling of the capsule and the presence of laser entrance holes causes non-uniform radiative heating, both resulting in further DT layer thickness variations.

One of the two leading candidates for target capsule ablator materials is copper-doped beryllium. Beryllium offers several significant advantages over the other leading ablator material (plastic), and one of these is its high thermal conductivity. We have hypothesized that the conductivity of copper-doped beryllium may be sufficiently high that the hohlraums will not need thermal shims and that the presence of thermal convection currents and laser entrance holes will be inconsequential.

We have initiated a program to measure  $\kappa_T$  of copper-doped beryllium alloys experimentally. We began by measuring both  $\kappa_T$  and the electrical resistivity  $\rho_T$  in separate experiments on a relatively pure beryllium specimen over the temperature range 10 K to 325 K. The data showed that even at the lowest temperatures, the Wiedemann-Franz law was closely obeyed, i.e.,

$\rho_T \kappa_T = L T$ , where the Lorenz number  $L = 2.45 \times 10^{-8} \text{ W} / \text{K}^2$ . Because dilute alloys typically follow the Wiedemann-Franz Law even more closely than do pure materials, we should not need to make both kinds of measurements for subsequent specimens. We have therefore elected to measure only  $\rho_T$  because it is the simpler measurement to perform. The  $\rho_T$  results for six different specimens are shown in Fig. X and are outlined in Table Y. The three specimens with the lower  $\rho_T$  values are all 'pure' beryllium, prepared by different methods. The lowest of those three is made from hot isostatically pressed (HIP) powder, while the higher two are both made by casting from the melt. The three specimens with the higher  $\rho_T$  values are all 6 wt. % Cu-Be. The two lowest of that set are both made from HIPped powder. Clearly, the effect of adding the Cu

overrides the effect of different sample preparation methods. Using the Wiedemann-Franz law, we calculate 20 K:

$\kappa_{20\text{ K}} = 1.12\text{ W/cm K}$  for the pure, HIPped Be, and  
 $\kappa_{20\text{ K}} = 0.14\text{ W/cm K}$  for the 6 wt. % Cu-Be alloys.

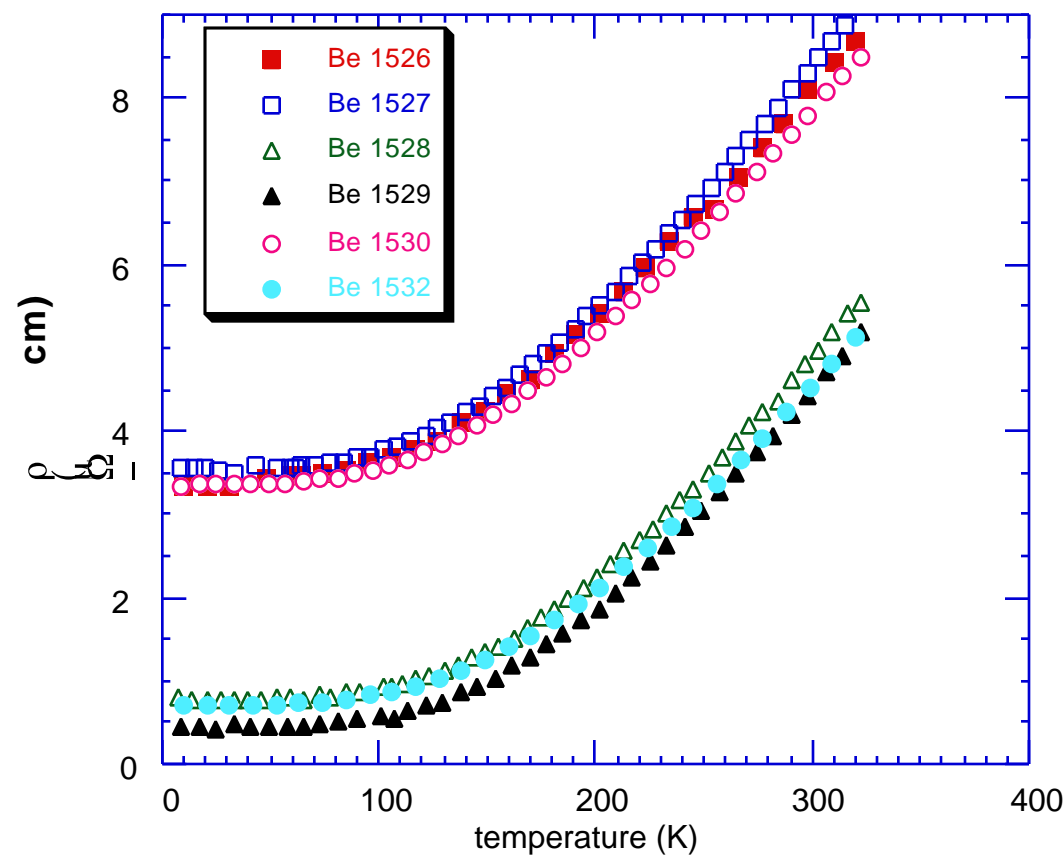


Fig. 1. Measured electrical resistivity of six Be specimens. See table Y for a summary of the data.

Table Y				
Sample No.	Description	$\rho_{20\text{ K}}$ (μ cm)	Residual Ratio $\rho_{293\text{ K}} / \rho_{20\text{ K}}$	$\kappa_{20\text{ K}}$ (W/cm K) (L 20 K/ $\rho_{20\text{ K}}$ )
Be 1526	6 wt. % Cu - HIPped	3.38	2.35	0.15
Be 1527	6 wt. % Cu - cast	3.58	2.30	0.14
Be 1528	Pure - cast	0.753	6.15	0.65
Be 1529	Pure - HIPped	0.436	9.82	1.12
Be 1530	6 wt. % Cu - HIPped	3.41	2.28	0.14
Be 1532	Pure - cast	0.715	6.09	0.69

The value of  $\kappa_T$  for the Cu-Be alloys is ~ 140 times better than that for typical plastics. Hence we predict that computer modeling of beta-layering within 6 wt. % Cu-Be alloy

shells will show no significant perturbations due to the presence of an unshimmed cylindrical hohlraum, nor due to the presence of thermal convection currents in the hohlraum gas and thermal radiation from the laser entrance holes.

